Effect of Goats on Great Island, Three Kings: The Permanent Quadrats Resurveyed.

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The Permanent Quadrats in 1948.

On 6th October, 1948, a landing on Great Island was made from the launch "Alert" but only four hours were spent ashore. The party included E. G. Turbott and L. C. Bell.

Insufficient time was available before dark to take a complete series of photographs corresponding to those of 1946, but representative ones were secured on each of the quadrats—Plates 15-17, figs. 1-6.

The following observations are a condensation of Turbott's field notes on Quadrats I and II with the addition of information supplied by Bell on Quadrat III.

Quadrat I

The most striking addition to the cover of Quadrat I was drifts of *Colensoa physaloides,* a plant not represented at all on this plot before the goats were exterminated. *Tetrapathea tetrandra* was another addition noted as widely distributed. Abundant new shoots had put out from the lower parts of the trunks of *Cordyline australis* (especially), *Melicytus ramiflorus* and *Litsaea calicaris. Clematis indivisa* seedlings were noted adjacent to the groups of parent plants recorded in 1946. [All the lianes of *Clematis* appeared to be of about the same age in 1951 and the groups did not appear to have extended their territory, so these seedlings probably have not survived.] Seedlings up to 3′ of *Meryta sinclairii* and *Brachyglottis arborescens* were frequent, especially about the position marked "P" in Pl. 24, fig. 18.

The four marked seedlings (see Turbott, 1948, p. 267) were remeasured:

No. 1. *Melicope ternata*	2′ 10″ high
No. 2. *Melicytus ramiflorus* (thought to be *Litsaea calicaris* in 1946)	1′ 4″ high
No. 3. *Melicope ternata*	2′ 6″ high
No. 4. *Tetrapathea tetrandra* (thought to be *Litsaea calicaris* in 1946)	2′ 0″ high

[In 1951, Nos. 2 and 4 could not be identified and probably have not survived. The nearest plant to 2 was a *Melicytus* (1′ 9″), but this was on the side facing away from the number. There was no seedling at all adjacent to No. 4.]

Quadrat II

Changes on this plot were much less remarkable than on I, but seedlings of *Meryta sinclairii, Cordyline australis, Tetrapathea tetrandra* and *Clematis indivisa* were observed. [The last named did not survive until 1951.]

Among the herbs, *Dianella intermedia* had already established several clumps and there were a few of *Arthropodium cirrhatum*. Both these plants were not present in the quadrat in 1946. It was recorded that the herbs, generally, were more flourishing than they had been during the goat occupation.

Quadrat III

Invasion of this grassland area by kanuka seedlings had begun and the sward itself was longer than in 1946.

The Permanent Quadrats in 1951.

The opportunity was taken during the 1951 Auckland Museum Expedition to the Three Kings Islands to re-map the permanent quadrats laid down by E. G. Turbott in 1946 (Rec. Auck. Inst. Mus., 1948, q.v.). Observers in the meantime (Baylis, 1951) have remarked the obvious and rapid changes which have occurred in the vegetation of Great Island since the extermination of the goats, but a remapping of the quadrats establishes these changes in numerical terms—an interval of about five years since the last census seems appropriate and it is hoped that it will be possible to take subsequent censuses at the same interval.

Methods

When Turbott made the original observations on these plots, the vegetation on each was so open that mapping could be accomplished by sighting on to flag markers set up on the side lines. On Quadrat I, this is no longer possible. The vegetation is already so dense that vision is limited to a few metres and it was found necessary to lay a grid of strings (two-metre squares were adopted) over the whole plot. Turbott himself gave assistance in finding the boundaries of this quadrat, but even so it is evident from a comparison of his Plate 50, fig. 20, with Plate 23, fig. 17, that there are discrepancies in the positions of individual trees between the two records. Errors thus introduced have been allowed for in the discussion that follows.

Quadrat I

In Turbott's photographs of this quadrat, taken in 1946, the vegetation looks old and decrepit for the trees are overaged and there is no new growth below. Now, in 1951, although the condition of the kanuka trees has still further declined, the forest looks quite flourishing, for the upspringing of large numbers of tree seedlings has added a fresh greenness to the plant cover. In some places the appearance of rejuvenescence has been intensified by vigorous growth of the passion vine, and in others by the spread of *Colensoa*.

Along the western boundary, however, there is relatively little change in the appearance of the forest (Cf. particularly fig. 7 with Turbott's fig. 3). Roughly, this zone corresponds with a belt of cabbage trees as shown in Turbott's Pl. 50, fig. 20, and Pl. 23, fig. 17, here. Pl. 24, fig. 18, in which the young trees are plotted, shows also a wide band free of seedlings down the right half of the diagram. But this area has nevertheless changed in general appearance since 1946, for here has appeared a dense swathe of *Colensoa* along both branches of the watercourse shown in Turbott's diagrams.

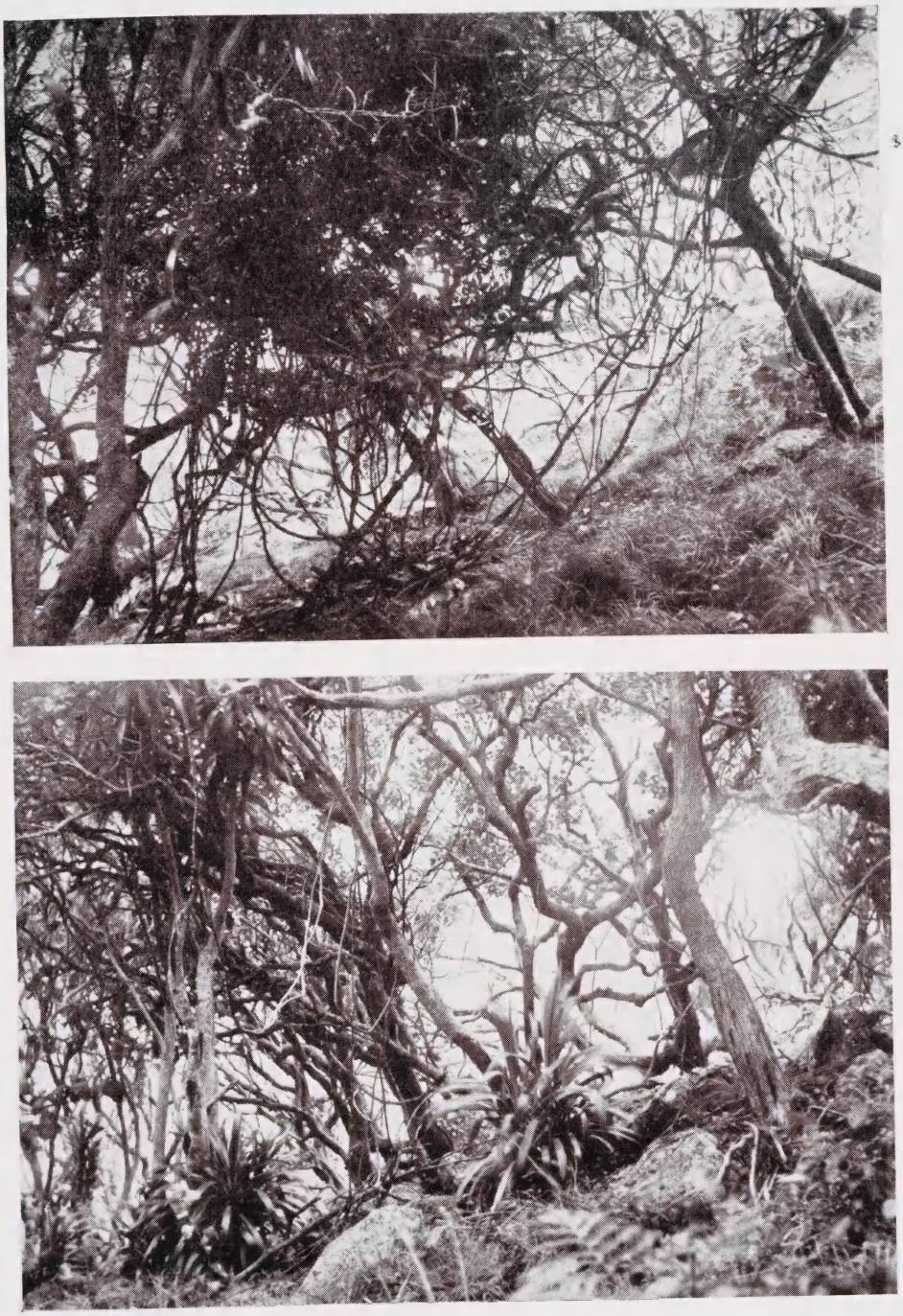

Fig 1. Quadrat I, 6th October, 1948. (Corresponds to Fig. 3A in Turbott, 1948.) The sedges are more luxuriant than in 1946.

Fig. 2. Quadrat I, 6th October, 1948. (Fig. 4B in Turbott.) Vigorous new shoots have grown from the bases of the cabbage trees. The fern in the foreground is *Pteris comans* and the bush to its right is *Melicytus ramiflorus*.

Photos: E. G. Turbott.

The canopy

Analysis of Turbott's diagram shows that, in 1946, the canopy was constituted by 92 mature trees rooted inside the quadrat, of which 50 were kanuka and 29 cabbage trees, other species contributing but a few specimens each. By 1951, the total number had fallen to 80. The figures are not exactly comparable, for there are some discrepancies between the two records in the inclusion of trees on the boundary lines. However, from their positions it is possible to identify 91 of the trees present in 1946 in Pl. 23, fig. 17. Of these, 19 (all kanuka) are represented now by dead boles, i.e., in five years more than a third of the mature kanuka trees have died.

Most of the gaps in the stippling representing the canopy in Pl. 23, fig. 17, can be related to the positions of the dead trees, the rest are gaps already present in 1946, probably marking the positions of trees which had died previously to Turbott's census.

The undergrowth

Though the total number of trees forming the canopy has declined by a fifth, the loss has been more than compensated for by the appearance of seedlings. These are not, however, kanukas. On this quadrat there are in fact no kanuka seedlings that can be said with certainty to be new. It is true that the total of them is now 73 compared with 43 in Turbott's diagram, but there are still none outside the two thickets shown there and the difference is almost certainly due to the difficulty of defining a single plant in a thicket.

The other young trees and bushes recorded by Turbott were: *Melicope ternata*, 15 seedlings; *Coprosma rhamnoides*, 9; and *Myoporum laetum*, 7. The present complement of this layer of vegetation is shown in Pl. 24, fig. 18, and summarised in Table 1: It can be seen that first place has now passed to mahoe, with almost as many seedlings as the rest put together. Kanuka has fallen to second place and ngaio has actually declined.

Geniostoma, *Brachyglottis* and *Entelea* were not present on the plot in 1946, and *Meryta*, as far as can be known, was not present anywhere on Great Island.

Table 1.

QUADRAT I.

Trees forming the canopy:

	1951	1946 (from E.G.T.)
Leptospermum ericoides A. Rich.	34	50
Cordyline australis (Forst. f.) Hook. f.	33	29
Melicope ternata Forst.	5	5
Litsaea calicaris (A. Cunn.) Hook. f.	4	4
Paratrophis smithii Cheesem.	2	2
Melicytus ramiflorus Forst.	1	1
Pittosporum fairchildii Cheesem.	1	1

Young trees and shrubs:

Melicytus ramiflorus Forst.	238	0
Leptospermum ericoides A. Rich.	73	43
Litsaea calicaris (A. Cunn.) Hook. f.	52	0
Melicope ternata Forst.	51	15
Coprosma rhamnoides A. Cunn.	27	9
Meryta sinclairii (Hook. f.) Seem.	15	0
Cordyline australis (Forst. f.) Hook. f.	7	0
Myoporum laetum Forst.	5	7
Paratrophis smithii Cheesem.	5	0
Pittosporum fairchildii Cheesem.	4	0
Entelea arborescens R. Br.	3	0
Geniostoma ligustrifolium A. Cunn.	3	0
Brachyglottis arborescens Oliver	2	0

No significant numbers can of course be quoted for the individual plants of the lianes *Muehlenbeckia complexa*, *Tetrapathea tetrandra* and *Clematis indivisa*, but the first is a new arrival on this plot with about 5 established colonies; *Tetrapathea* has certainly increased since 1946 (about 40 colonies); whereas *Clematis* is confined to the same 3 colonies marked by Turbott. Established seedlings around the parent plants were recorded by Turbott in 1948 but these do not seem to have survived.

The Herbs

Most of the ground herbs mapped in Pl. 25, fig. 19, could not be recorded as individuals; furthermore, the stippling used to represent the grasses and sedges records only whether they were present at all in the squares of the grid, not the actual area covered.

The most conspicuous event in the ground layer has been the invasion of the damper parts of the quadrat by *Colensoa physaloides*. The areas affected are almost pure stands of this plant—the only herb which has survived being engulfed by *Colensoa* is *Pteris comans*. With the exception of 5 remaining tussocks, *Colensoa* has completely cleared the watercourses of the *Carex* shown in Turbott's Pl. 51, fig. 21.

The areas bare of ground cover are approximately the same as indicated by Turbott—a large space in the S.W. quarter of the plot, two spaces under the young kanuka trees and patches along the W. boundary. However, the large area in the S.W. quarter, truly bare in 1946, is now a shrubbery of tree seedlings (cf. Pl. 24, fig. 18, and Pl. 25, fig. 19).

No attempt, on this occasion, was made to sort out the composition of the areas occupied by "grasses." Casual survey, however, showed that the principal components are still *Oplismenus undulatifolius* and *Echinopogon ovatus*, as recorded by Turbott. The squares marked as containing "sedges" included very little *Carex virgata*, which has probably declined in favour of *C. testacea* since 1946.

Two new arrivals among the plot's complement of herbs are *Erigeron canadensis* and *Haloragis erecta*. The first was not recorded anywhere on the island by Baylis in 1946 (see list, p. 247 et seq. Baylis, 1948). It is now found sporadically everywhere in the open kanuka forest, but is not frequent on the plot itself and has not been recorded in Pl. 24, fig. 19. *Gnaphalium collinum* and *Oxalis corniculata* are probably now absent from this plot, but no opinion can be given about the other small herbs mentioned by Turbott as they were not specifically looked for in 1951.

Fig. 3. Quadrat I, 6th October, 1948. (Fig. 5C in Turbott.) Young kanuka in opening, new shoots arising from the trunk of *Cordyline australis*. *Colensoa physaloides* in right foreground. The young *Entelea arborescens* in the left foreground had completely obscured this view by 1951.

Fig.4. Quadrat I, 6th October, 1948. (Fig. 8F in Turbott.) Sedges more luxuriant than in 1946. *Colensoa physaloides* has appeared along the water-courses (centre and right foreground). Young *Melicope ternata* and *Brachyglottis arborescens* in right foreground.

Photos: E. G. Turbott.

Fig. 5. Quadrat II, 6th October, 1948. (Fig. 10H in Turbott.) Sedges more luxuriant than in 1946. *Coprosma rhamnoides* in centre and to right. Young *Cordyline australis* and *Dianella intermedia* in line to extreme right.
Photo: E. G. Turbott.

Fig. 6. Quadrat III, 6th October, 1948. (Fig. 13L in Turbott.) The tussocks are *Scirpus nodosus*. The young kanuka seedlings shown by 1951 (Pl. 22, fig. 15) are not yet apparent. The white lines are the boundaries of the plot with the west corner in the foreground.
Photo: L. C. Bell.

Quadrat II

As can be seen by comparing Pl. 45, figs. 9 and 10, in Turbott's paper with Pl. 21, figs. 13 and 14, superficially little change has occurred in the general appearance of this plot, for the tree seedlings are still too small to add an additional layer to the vegetation. However, the areas of turf have mostly been replaced by sedges throughout the whole plot and *Dianella* is a new and prominent component of the herb layer.

With the exception of the cabbage tree in the E. corner, Turbott did not mark the positions of the trees on this quadrat, but records that the canopy was constituted by 46 kanuka trees. The total number of live trees shown in Pl. 26, fig. 20, for the same area is now only 21, including this same cabbage tree. On this plot, too, then, mortality among the kanuka trees has been high, but whereas there is no evidence of regeneration since 1946 on Quadrat I, on this plot there are a few (five) young bushes additional to the thicket shown by Turbott. *Coprosma rhamnoides*, which Turbott mentions as "scattered over the quadrat," is still the dominant shrub and the most numerous tree seedlings are of the cabbage tree. The full complement of tree seedlings is shown in Table 2. The *Melicope* is the same specimen recorded by Turbott and it has grown very little since. During the 1948 landing this tree was noticed to have been severely damaged by cicadas.

Table 2.

Shrubs and tree seedlings recorded on Quadrat II, January, 1951:

	Number of Plants.
Coprosma rhamnoides A. Cunn.	75
Cordyline australis (Forst., f.) Hook. f	17
Leptospermum ericoides A. Rich.	12
Meryta sinclairii (Hook. f.) Seem.	8+
Litsaea calicaris (A. Cunn.) Hook f.	4+
Paratrophis smithii Cheesem.	3+
Melicytus ramiflorus Forst.	2+
Myoporum laetum Forst.	1+
Melicope ternata Forst.	1

Those marked + are new records since 1946.

Only the larger herbs have been recorded individually, and the shading representing *Doodia media* and *Carex (testacea)* in Pl. 26, fig. 20, merely indicates whether these were present in the grid squares. There was no bare ground on this plot except beneath the kanuka bushes: the squares shown blank in the diagram being actually occupied by turf. The nature of this was not investigated carefully, but the principal component was *Oplismenus undulatifolius*.

A list of the larger herbs present is given in Table 3.

Table 3.

Larger herbs recorded on Quadrat II, January, 1951:

	Number of Plants.
Erigeron canadensis L.	30+
Haloragis erecta Schindler	17+
Dianella intermedia Endl.	11+
Arthropodium cirrhatum (Forst. f.) R. Br.	1+
Davallia tasmani Cheesem.	1+

Those marked + are new records since 1946.

Quadrat III

More change has occurred in the general features of Quadrat III than is apparent from a comparison of Pl. 22, figs. 15 and 16, with Turbott's Pl. 47, figs. 13 and 14. The greater part of the plot is still occupied by a short turf of mixed grasses and other herbs, but the interspersed tussocky growth which can be seen in Turbott's photographs is *Scirpus nodosus*, whereas in Pl. 22, figs. 15 and 16, almost the same appearance is given to the photographs by the swarm of windswept cushions of kanuka which has spread west from the original scrub in the north corner. Most of this change has become apparent since 1948 (cf. L. C. Bell's photograph, Pl. 17, fig. 6, with fig. 15), though both Baylis (Baylis, 1948; Turbott, 1948) and Bell recorded the establishment of new kanuka seedlings.

On the other hand, the amount of *Scirpus* has probably not altered —the positions of this shown in Turbott's Pl. 52, fig. 23, correspond with those in Pl. 17, fig. 21 (in the latter it occupies 2.1% of the total area). This means that the area in turf has declined, for the area occupied by kanuka has certainly increased. The area now occupied by *young* kanuka is 24.4% of the total, and though it is not possible to extract a figure from Turbott's data for comparison, the kanuka in his diagram occurs in only two groups of bushes, one of which, that in the N. corner, is now dead. Young trees are already established under the dead branches.

The sedges which Turbott noted under this group of bushes still persist. Beneath the dense cover of the new kanuka, on the other hand, the ground is quite bare.

The composition of the grass sward is presumably much the same as it was in 1946. The following table (Table 4) is an analysis of the strip of metre squares against the S.W. boundary.

Table 4.

Frequency of herbs forming the turf of Quadrat III.

	No. of squares (out of 15) in which species occurred.
Centella asiatica (L.) Urban	15
Deyeuxia crinita (L.) Zotov	15
Aira caryophyllea L.	10
Vulpia dertonensis (All.) Volk.	10
Wahlenbergia gracilis (Forst. f.) Schrad.	9
Aira praecox L.	8
Gnaphalium collinum Lab.	8
Sonchus oleraceus L.	6
Danthonia semiannularis R. Br.	5
Hypochoeris radicata Lab.	5
Oxalis corniculata L.	3
Zoisia matrella (L.) Merrill	3
Carex breviculmis R. Br.	1
Cotula australis (Lieb.) Hook. f.	1
Dichondra repens Forst.	1
Doodia media R. Br.	1
Erigeron canadensis L.	1
Hydrocotyle novaezelandiae D.C.	1

With the exception of *Erigeron canadensis*, it is doubtful whether any of these are new to the plot, for unless they are in flower it is difficult to separate the grasses and probably even this list is not exhaustive.

Fig. 7. Quadrat I, 14th January, 1951. (Corresponds to Fig. 3A in Turbott, 1948.) The white line across the upper part of the picture is the string marking the W. boundary of the plot. The seedling obscuring the right foreground is *Melicytus ramiflorus*.

Fig. 8. Quadrat I, 14th January, 1951. (Fig. 4B in Turbott.) New growth from base of *Cordyline australis* in centre and left. Ground now covered with *Carex*. Young *Melicytus* in foreground and to right. The fern is *Pteris comans*.

N.B.—The view corresponding to Turbott Fig. 5C was completely obscured by a young *Entelea arborescens*.

Fig. 9. Quadrat I, 14th January, 1951. (Fig. 6D in Turbott.) *Coprosma rhamnoides* in centre foreground. *Colensoa physaloides* at base of tree on right. Young *Leptospermum ericoides* on left. The white string is the N. boundary of the plot.

Fig. 10. Quadrat I, 14th January, 1951. (Fig. 7E in Turbott.) New growth from base of *Cordyline* on left. *Colensoa* obscuring foreground.

DISCUSSION.

(a) Regeneration of kanuka forest

On neither Quadrat I nor II is there any evidence that the existing kanuka forest is being replaced as the old trees die out. Thus on both a change to some other type of forest can be forecast. On both the rate of change is rapid: Since 1946, 39% of the kanukas on Quadrat I have died and probably 67% on Quadrat II; yet there is no good evidence of the appearance of a single new kanuka seedling since 1946 on Quadrat I and only a 19.2% replacement on II. On both quadrats there were groups of kanuka seedlings in 1946, and, at least on Quadrat I, it is clear that these had appeared below the only breaks in the canopy, i.e., while the goats were in occupation, the only factor keeping back the growth of new kanukas was the shade cast by their parents, and the appearance of a gap anywhere in the canopy immediately induced a replacement crop more than sufficient to fill the gap.

With the goats removed the sequence is quite different. Kanuka seedlings are still not tolerant of the parental shade, but they are not able to exploit the open spaces either. This is not a question of competition with other tree seedlings, for on Quadrat I the principal open spaces are almost free of them (excepting, of course, the kanuka seedlings existing pre-1946) and on Quadrat II the association of other tree seedlings is nowhere dense enough to offer resistance to colonisation. The reason is therefore probably the coverage provided by the herbs, which is, in fact, most dense below gaps in the canopy. The principal plants involved are *Colensoa* and the sedges (the grass is nowhere very vigorous), the former of which was completely controlled by the goats and the sedges though present before 1946 are now much taller and denser (cf. in Pl. 18, fig 7, with Turbott, Pl. 42, fig. 3).

Thus, through the control that by browsing and trampling they exercised on the coarser herbs, the goats were responsible for the maintenance of the kanuka cycle in the forested part of the island. On the other hand, they also suppressed the seedlings of other trees which are the natural heirs of the kanuka. The degree of regeneration still taking place on Quadrat II reflects the general dryness and poverty of the soil on this plot compared with Quadrat I: the ground herbs are less flourishing and can offer less resistance to the entry of kanuka seedlings.

On Quadrat III, the situation is quite different. The hillside is too windswept to maintain high kanuka forest; instead, the same species here can only attain the status of a stunted and matted scrub. Baylis (1948) has pointed out that the occupation of this area by grass was probably the result of a fire a long time ago (probably even before Cheeseman's visit in 1889) and the goats have delayed its recolonisation by kanuka by inadvertent grazing of seedlings in the sward.

Since the removal of the goats the recolonisation has been greatly accelerated and the grass will presumably eventually be excluded altogether, though in five years less than a quarter of the sward has disappeared on this particular plot.

(b) Alternatives to the kanuka cycle

Though it is certain that the succession of kanuka trees that have forested Quadrats I and II has now come to an end, what is to replace it is not yet defined.

On Quadrat I, mahoe forms nearly half of the generation of seedlings that has sprung up since the goats were eliminated (Table 1). Yet this apparent dominance is probably a temporary phase due to the initial advantage of a freely fruiting parent plant of the same species on the plot. On Quadrat II, for example, mahoe occupies quite a low place in the order of frequency, this plot being further from a seed source. Mahoe dominated forest is occasionally met with (e.g., as a sub-association of rain forest—Thompson and Simpson, 1938), but mahoe is better known as a sub-dominant—a position which it commonly fills in the various types of coastal forest around New Zealand (Cranwell and Moore, 1935; Oliver, 1925, 1944; Hamilton, 1936).

Litsaea and *Melicope,* which follow in the list for Quadrat I, are again probably more numerous on this plot than would be expected in a random sample of the island's vegetation, because of the proximity of their respective seed sources. Both these species are handicappd in the race for succession by a very slow rate of growth. For example, two of the seedlings numbered by Turbott on Quadrat I were of *Melicope* (Turbott, 1948, p. 267) and were then respectively 6″ and 4″ high. Now, nearly five yeares later, they are only 4′ 9″ and 2′ 11″. For comparison, some of the *Meryta* seedlings which have appeared since 1946 are already over 8′. All the *Litsaea* seedlings seen also were small.

There are two species which have a fairly high proportion of seedlings on both plots—*Cordyline australis* and *Meryta sinclairii.* The first of these had a regular place in the forest before 1946, so that its frequent occurrence as seedlings everywhere now that the goats have gone was to be expected. Of *Meryta,* on the other hand, there was no seed source at all on Great Island in 1946, yet this, too, made an early appearance everywhere and on both quadrats it is already a prominent feature of the vegetation.

Baylis (1951 q.v.) has given reasons for anticipating the development of *Meryta* forest as the next successor to the kanuka. It has a very rapid rate of growth (exceeded here perhaps only by *Entelea*) and its large, leathery leaves cast a shade in which few competitors may be expected to struggle for long. Some of the seedlings on the plots will shortly be fruiting themselves, and then, with a nearer seed source than the outlying islands, the competition for dominance on these plots should shortly be decided.

On Quadrat III, the dominance that has been forecast for *Leptospermum ericoides* may here, too, be only temporary, though there is no evidence yet for this on the quadrat itself. However, pohutukawa seedlings, seeded no doubt from the surviving trees along Tasman Bay, have appeared in some numbers in exactly the same type of association not very far away from the quadrat. Since kanuka is so very light demanding, in competition with pohutukawa it may eventually be ousted from this quadrat also.

(c) Shade tolerance of seedlings

It has already been assumed that *Leptospermum* seedlings cannot grow in the shade of the canopy cast by the same species. This is an extreme intolerance, for the canopy of mature kanuka is not particularly dense and within its shade a great number of other species both of herbs

Fig. 11. Quadrat I, 14th January, 1951. (Fig. 8F in Turbott.) *Entelea arborescens* in background. *Colensoa physaloides* filling water-course from right background to left foreground. *Haloragis procumbens* in right foreground. The sedges shown in Fig. 4 (1948) have now largely been suppressed. The white string is the E. boundary of the plot.

Fig. 12. Quadrat I, 14th January, 1951. From point P in Pl. 24, fig. 18. Young *Meryta sinclairii*. *Pteris comans* in foreground. Young *Melicytus ramiflorus* in centre.

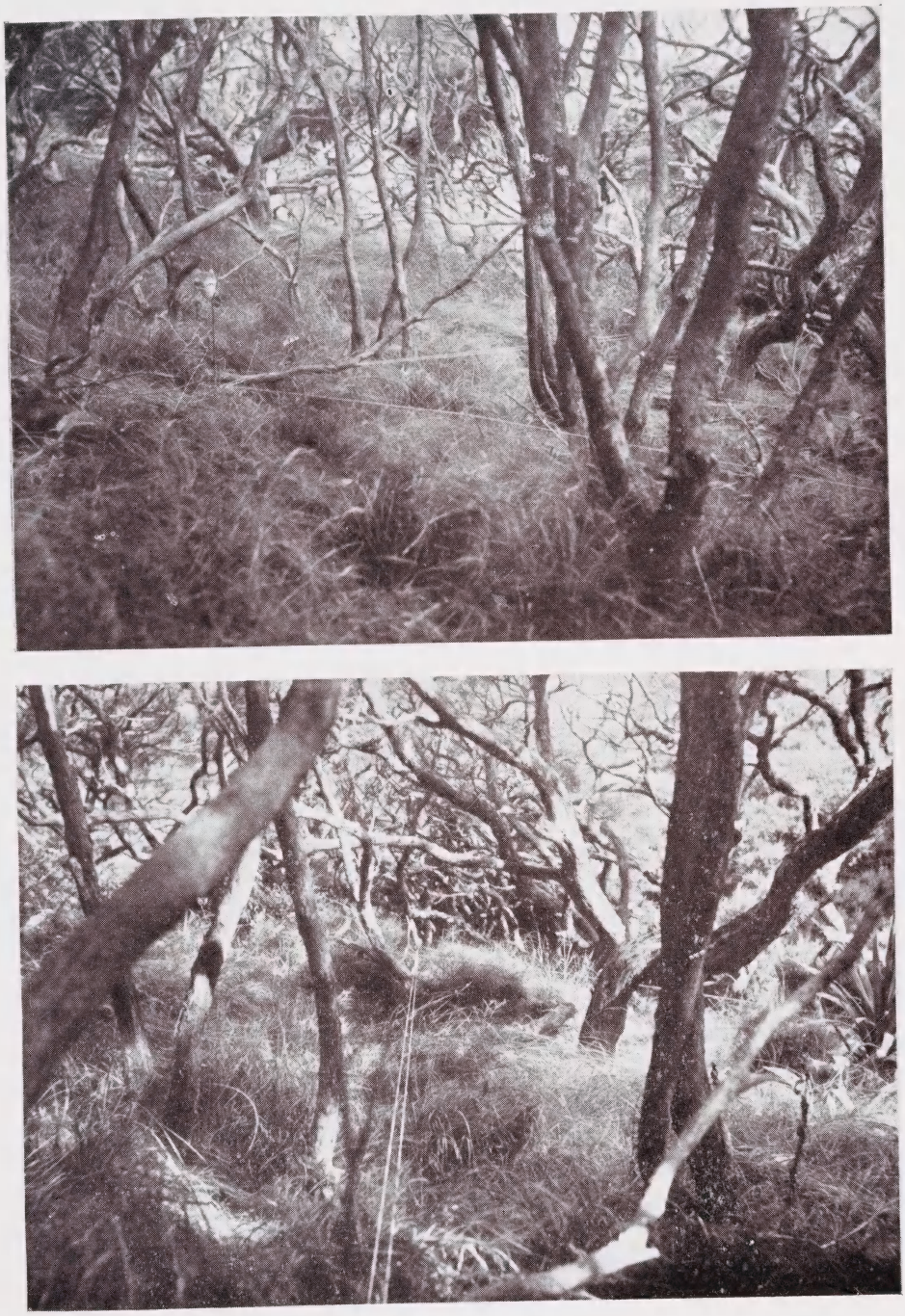

Fig. 13. Quadrat II, 11th January, 1951. (Fig. 9G in Turbott.)
N.B.—The direction of this photograph is as in Pl. 26, fig. 20; direction is shown wrongly in Turbott, Pl. 52, fig. 22.

Fig. 14. Quadrat II, 11th January, 1951. (Fig. 10H in Turbott.) Young *Cordyline* at back right and a plant of *Arthropodium cirrhatum* immediately in front of it.

Photos: E. G. Turbott.

and tree seedlings are flourishing. Among them are included *Meryta, Melicytus* and *Colensoa,* etc., often themselves quoted as light demanding. The shade cast by the cabbage trees along the W. boundary and by the isolated trees of *Paratrophis* and *Melicope* is much deeper and below these the ground is almost bare. The only tree seedlings that have established themselves in this deep shade are all of *Litsaea calicaris.* Abundant seedlings of this same species are also growing in the thickets of *young* kanuka where otherwise the ground is absolutely bare. This suggests that over a long period of time *Litsaea,* in spite of its slow growth, will become an important constituent of the forest as it will not have to await the death of a canopy tree—whatever that canopy is composed of—before establishing itself.

(d) Other barriers to forest regeneration

Reference to Pl. 24, fig. 18, shows that on Quadrat I the seedlings of any species are numerous only in the S.W. quarter of the plot. This area almost exactly coincides with the area shown as bare ground in Turbott's Pl. 51, fig. 21. It thus seems clear that the herb layer, already considered as controlling kanuka, is also a barrier to colonisation by other species, whether it has the assistance of shade from the canopy or not. The large, coarse herbs *Colensoa* and *Carex testacea* are the most important, of which *Colensoa* is the more aggressive and has successfully competed with the *Carex* itself. All the area now occupied by *Colensoa* is shown in *Carex* in Turbott's diagram.

Colensoa is undoubtedly a brake on the rate of colonisation of Great Island by new trees, but it is everywhere limited to the wetter stations—along watercourses and at the base of damp cliffs. Thus on Quadrat II, which is dryer than I, it is absent altogether. Moreover, it has probably already attained the limit of possible colonisation even on Quadrat I. So the restraint which it can exercise on regeneration is limited. Furthermore, it is not tolerant of extreme shade (e.g., it is absent from the cabbage tree belt) and will not in any case survive the dominance of *Meryta.*

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Fig. 15. Quadrat III, 10th January, 1951. (Fig. 13L in Turbott.). *Leptospermum* scrub on left, culms of *Deyeuxia crinita* can be seen in front of them. The white lines are the boundaries of the plot with the E. corner at left centre.

Fig. 16. Quadrat III, 10th January, 1951. (Fig. 14M in Turbott.) The white lines are the boundaries of the plot towards the W. corner.

Photos: G. T. S. Baylis.

Fig. 17—QUADRAT I.

POSITION OF TREES CONTRIBUTING TO THE CANOPY AND ITS APPROXIMATE DENSITY (stippling).

Extent of the canopy and the positions of the trees contributing to it.

c —*Cordyline australis.*

l —*Litsaea calicaris.*

k —*Leptospermum ericoides.*

m —*Melicytus ramiflorus.*

t —*Melicope ternata.*

p —*Pittosporum fairchildii.*

s —*Paratrophis smithii.*

○ —Dead tree still standing (*Leptospermum*).

i —*Clematis indivisa* (liane).

The density has been plotted on the basis of two metre squares—

indicates square entirely shaded.

square partly shaded, by canopy.

The diameter of the boles shown is arbitrary.

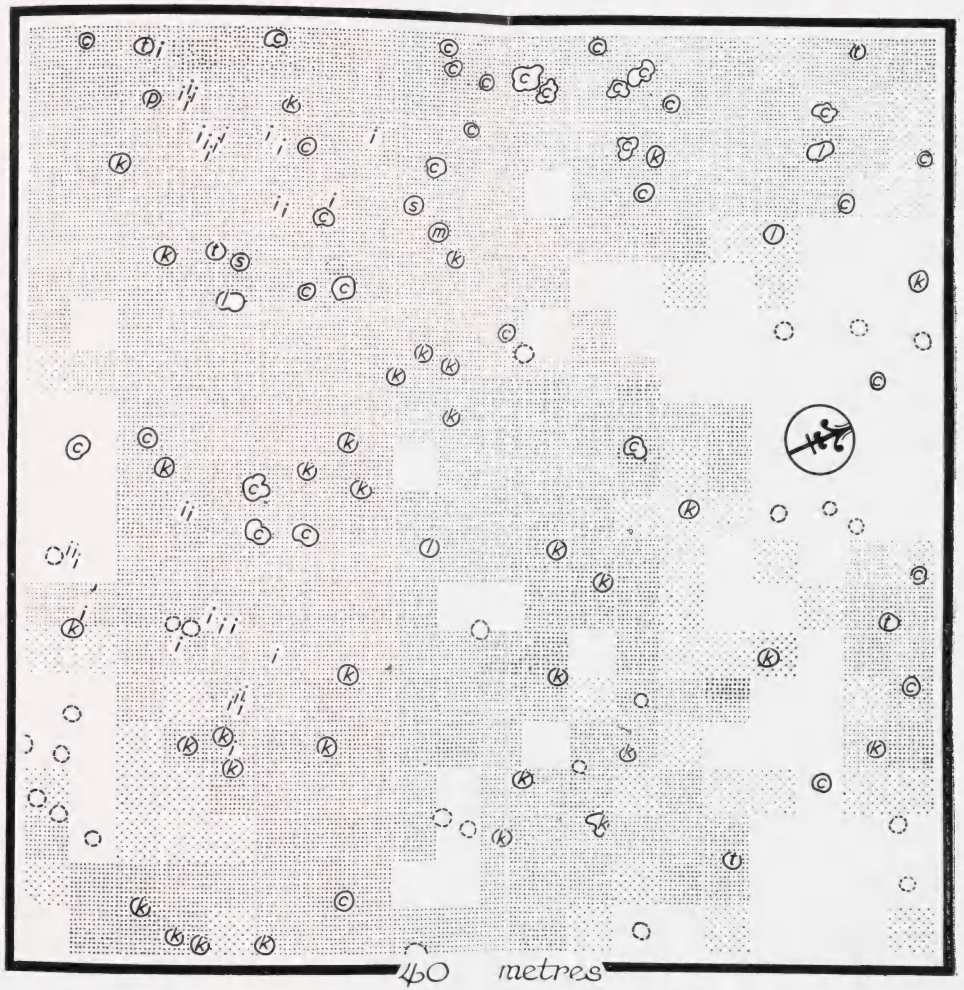

Fig. 18—QUADRAT I.

POSITION AND RELATIVE SIZE OF YOUNG TREES AND SEEDLINGS.

a —*Tetrapathaca tetrandra.*

b —*Brachyglottis arborescens.*

c —*Cordyline australis.*

E —*Entelea arborescens.*

g —*Geniostoma ligustrifolium.*

k —*Leptospermum cricoides.*

l —*Litsaea calicaris.*

m —*Melicytus ramiflorus.*

n —*Myoporum laetum.*

p —*Pittosporum fairchildii.*

r —*Coprosma rhamnoides.*

s —*Paratrophis smithii.*

t —*Melicope ternata.*

u —*Muehlenbeckia complexa.*

y —*Meryta sinclairii.*

1&3 —Seedlings (*Melicope*) marked by Turbott.

(2),(4) Position of seedlings marked by Turbott which have not survived.

—extent of canopy made by young *Leptospermum* trees (up to 15′ high).

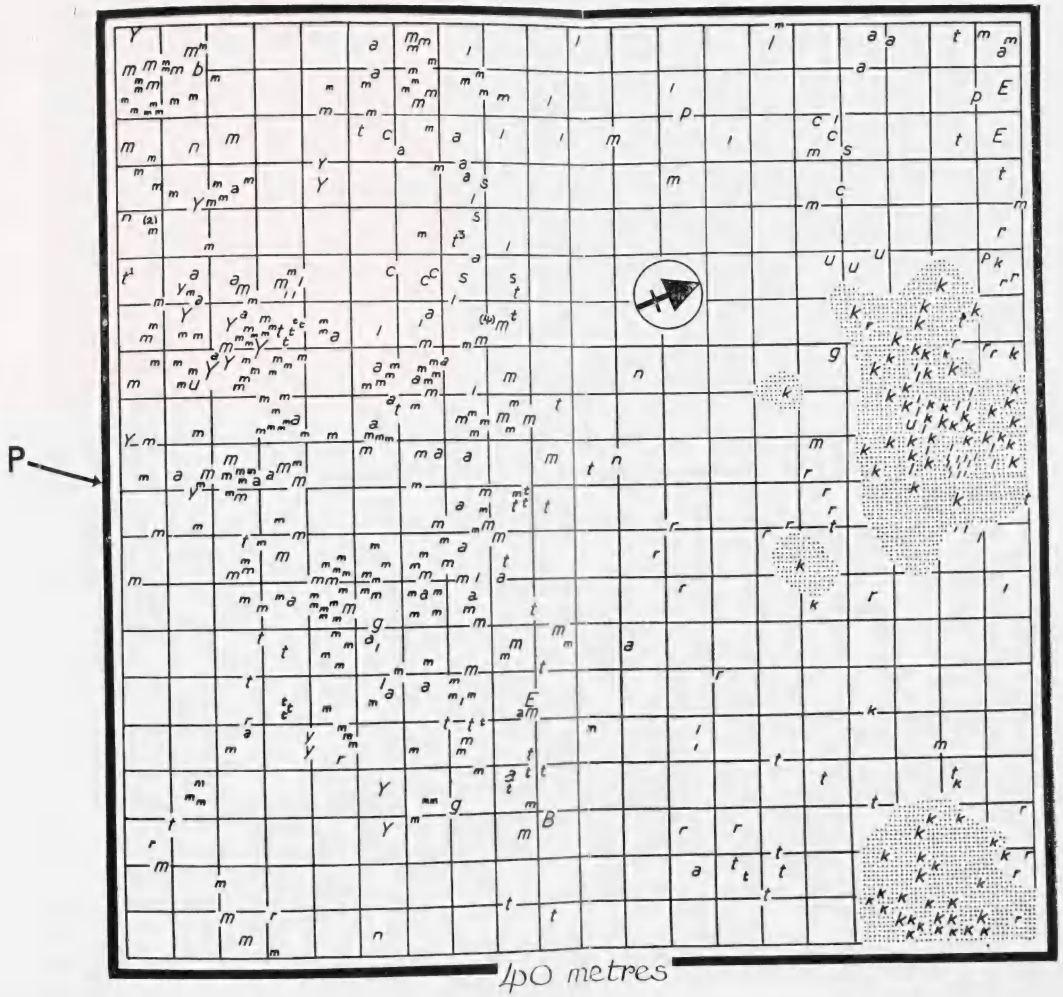

Fig. 19—QUADRAT I.

POSITION AND COVERAGE OF HERBACEOUS PLANTS.

d —*Dianella intermedia.*

f —*Pteris comans.*

h —*Haloragis procumbens.*

—*Carex testacea* and *virgata* (plotted as 2 metre squares).

—Grasses (plotted as 2 metre squares).

—*Colensoa physaloides.*

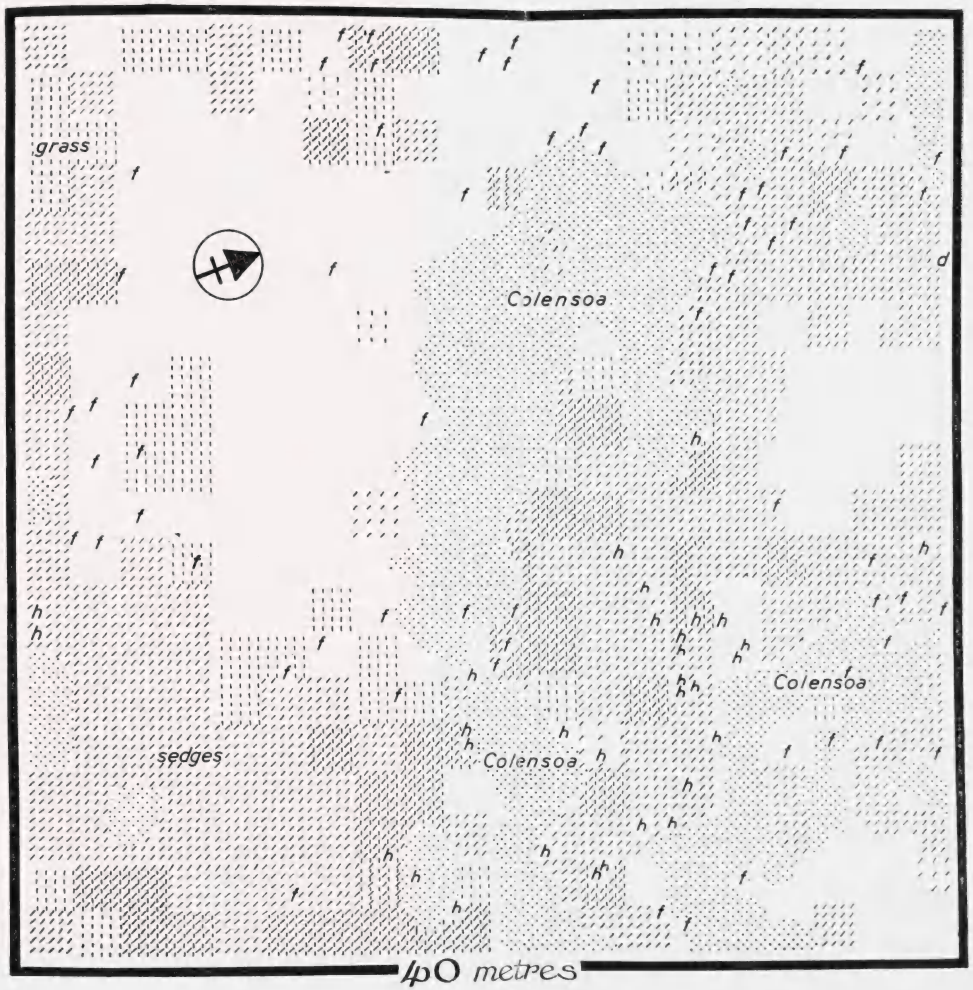

Fig. 20—QUADRAT II.

POSITION OF TREES AND SEEDLINGS AND DISTRIBUTION OF GROUND FLORA.

- *e* —*Tetrapathaca tetrandra.*
- *c* —*Cordyline australis.*
- Ⓒ —Ditto, mature tree.
- *d* —*Dianella intermedia.*
- *e* —*Erigeron canadense.*
- *h* —*Haloragis procumbens.*
- *k* —*Leptospermum ericoides.*
- Ⓚ —Ditto, mature tree
- *l* —*Litsaea calicaris.*
- *m* —*Melicytus ramiflorus.*
- *n* —*Myoporum laetum.*
- *r* —*Coprosma rhamnoides.*
- *s* —*Paratrophis smithii.*
- *t* —*Melicope ternata.*
- *v* —*Davallia tasmani.*
- *y* —*Meryta sinclairii.*
- *z* —*Arthropodium cirrhatum.*

- —Sedges *Carex testacea* present (estimated on squares of 1 metre).
- —*Doodia media* present (estimated on squares of 1 metre).
- —Coverage of shade cast by kanuka thicket.
- —Dead tree (*Leptospermum ericoides*).

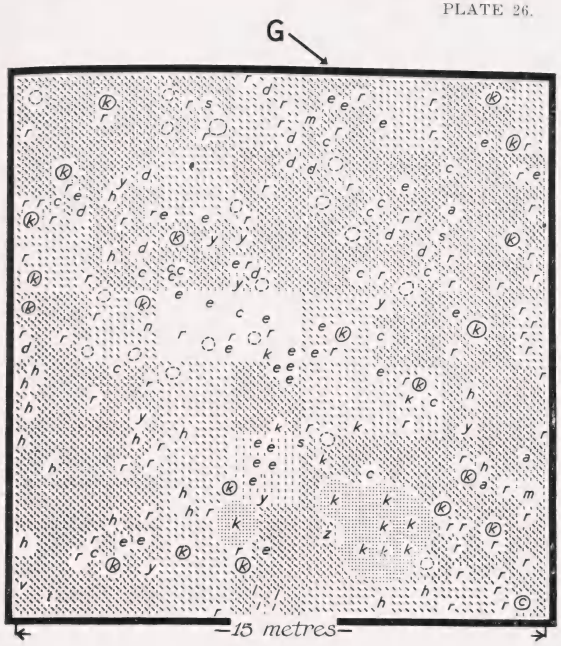

Fig. 21—QUADRAT III.

- —*Leptospermum ericoides.*
- —Ditto, dead.
- —*Scirpus nodosus.*
- —*Carex testacea.*
- —Grassy sward.